CDC
CENTERS FOR DISEASE CONTROL AND PREVENTION

# GLOSSARY OF TERMS

**Savannah River Site**
**Phase II of the SRS Dose Reconstruction Project**

**February 1999**

**Actinides** are radioactive elements with atomic numbers equal to or greater than that of actinium (i.e., 88). The term refers to the heaviest elements, starting with actinium and continuing to the end of the periodic table. *Transuranic* elements are a subset of the actinide elements and include those with atomic numbers larger than uranium (92). Actinide elements are all radioactive.

**Activation products** are radionuclides that result from the absorption of neutrons by uranium, or other materials. An example is plutonium-239 produced following neutron absorption by uranium-238 and subsequent decays of uranium-239 to neptunium-239 and then to plutonium-239.

**Activity** is the mean number of decays per unit time of a radioactive nuclide expressed as *disintegrations* per second. Units of activity are the becquerel (Bq, one disintegration per second), or the curie (Ci, 37 billion disintegrations per second).

**Alpha particle** (*ionizing radiation*) is two neutrons and two protons bound as a single particle (a helium nucleus) emitted from the nucleus of certain radioactive isotopes.. It deposits its energy very quickly while passing through matter. Plutonium-239 emits alpha particles.

**Atomic number is** the number of protons in the nucleus of an atom.

**Background radioactivity** refers to radioactive elements in the natural environment including those in the crust of the earth (like radioactive potassium, uranium, and thorium isotopes) and those produced by cosmic rays.

**Beta particle** (*ionizing radiation*) is a charged particle emitted from the nucleus of certain unstable atomic nuclei (radioactive isotopes), having the charge and mass of an electron. Energetic beta particles penetrate the dead skin layer. The beta particle is not stopped in matter as quickly as an alpha particle.

**Bias** is a systematic distortion of measurements that makes the results inaccurate. Accuracy is a measure of how close a value is to the true number, or a measure of the correctness of a measurement. Precision refers to the ability of an analytical method to reproduce the same result upon repeated trials.

**Bq** is an abbreviation for the SI unit of radioactivity, Becquerel. Equal to one *disintegration* per second. (See *curie.)*.

**CDC** (Centers for Disease Control and Prevention) is an agency of the Department of Health and Human Services. The CDC has 11 centers, offices and an institute. The CDC is a non-regulatory agency – its mission is to promote health and quality of life by preventing and controlloing disease, injury and disability. The CDC sponsors the Savannah River Site Dose Reconstruction Project and similar projects in Idaho, the Northwest and elsewhere.

**Chemical symbols** are abbreviations for different elements and compounds. Examples of symbols for elements include U for uranium, Pu for plutonium, O for oxygen, C for carbon and Cl for chlorine. Examples of symbols for compounds include $CCl_4$ for carbon tetrachloride and $PuO_2$ for plutonium dioxide.

**Concentration** is the amount of a material of interest in a given volume or mass.

**Contamination** – unwanted radioactive or other material or the deposition of radioactive material in the environment or other place where it may make surfaces or equipment unsuitable for some specific use.

**Coolant** refers to the fluid that cools the reactor. The primary coolant passes directly through and around the fissioning fuel in a reactor and carries away heat to prevent melting. The secondary coolant carries the heat away from the reactor and releases it to the environment. In the SRS reactors, the secondary coolant was water from the Savannah River or PAR Pond. The heat passes from the primary coolant to the secondary in heat exchangers.

**cooling (radioactive)** – the reduction of radioactivity and heat generation of irradiated fuel or target material by radioactive decay.

**critical mass** – the minimum mass of fissionable material which can achieve a nuclear chain reaction with a specified geometrical arrangement and material composition.

**Curie –** a unit used to describe an amount of radioactivity. The curie is equal to 37 billion *disintegrations* per second (dps). The internationally recognized unit of radioactivity is the Becquerel (Bq), which is one dps. Due to its historical context, this report favors use of traditional units for radioactivity. For environmental samples, the microcurie ($10^{-6}$ Ci), the picocurie ($10^{-12}$ Ci), or the femtocurie ($10^{-15}$ Ci) are often used.

**Disintegration** – one decay of a radioactive atom. *(See dpm.)*

**DOE** – U.S. Department of Energy. The DOE is responsible for the sites in the U.S. at which weapons materials have been produced or handled, including the Savannah River Plant. Generally, private *contractor*s, such as Du Pont have operated the weapons facilities for the DOE. *(See ERDA, AEC.)*

**Domain -** the area considered within the study**.** For this dose reconstruction the domain extends 50 miles in all directions from the SRS boundary; the domain also includes Columbia, SC and an area on either side of the Savannah River to the coast.

**Dose** is a general term denoting the quantity of *radiation* or energy that is absorbed by the body. There are technical terms with specific definitions, such as absorbed dose, equivalent dose, and effective dose.

**Dose Reconstruction** –a study process in which historical information is used to estimate the amounts of toxic materials released from a facility, how the materials could have moved offsite, and the exposure of the public to those materials. Dose Reconstruction involves past releases, not present, or future releases. The study period for this Savannah River Site Dose Reconstruction is 1951–1992.

**dpm** – abbreviation for *disintegrations* per minute, a rate of radioactive decay. There are 2.22 dpm per picocurie. (*See curie.*)

**Du Pont** – the Atomic Energy Commission appointed Du Pont to operate the site in 1950. They ran the site until March 30, 1989 when Westinghouse Savannah River Company took over the responsibility.

**Effluent** – a gas or liquid that flows from a process, building, or site into the surrounding environment.

**Effluent monitoring** – the measurement of a *contaminant* or other property (e.g. flow rate) in the effluent (air or liquid discharged) from a building or holding pond.

**EML** – Environmental Measurements Laboratory (*see HASL*).

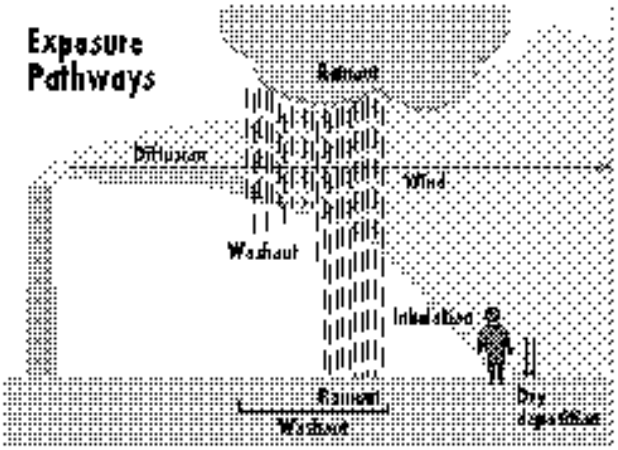
**Environmental monitoring** û the measurement of a material in the environment at regular time intervals. Monitoring for *contaminants* often involves the collection of an environmental sample, (like stream water), preparation of the sample in the laboratory, and analysis of the prepared sample using an analytical instrument.

**Environmental transport** – the mechanisms by which substances can be carried from their source to other points in the environment. Surface water runoff and air dispersion by wind are examples of environmental transport mechanisms.

**Exposure** (to hazardous substances) refers to conditions or circumstances causing humans or other living things to come into contact with toxic materials.

**Exposure pathways–** the means by which humans are exposed to toxic substances. The key exposure pathways are air and water, with most exposures via inhalation, drinking water, crops, other foods, and direct radiation.

**Fallout** refers to airborne particles containing radioactive material that fall through the atmosphere and are deposited on the earth's surface following the detonation of nuclear explosives.




**femto –** a prefix that multiplies a basic unit by 1/1,000,000,000,000,000 or 1 x $10^{-15}$. For example, 1 femtocurie equals 1 x $10^{-15}$ curie.

**Fission products** are radionuclides that result from the splitting or fissioning of heavy elements like uranium in a nuclear reactor. Examples are cesium-137, strontium-90, technetium, 99, and ruthenium-106.

**Gamma radiation** also gamma rays (*ionizing radiation*) û short wavelength electromagnetic radiation (photon) originating from the nucleus of a radionuclide. Gamma rays are similar to medical x-rays, but are emitted at very specific energies characteristic of their decaying atoms higher than about 100 keV. They penetrate tissue more effectively than beta or alpha particles, leaving ions in their path to potentially cause cell damage. Gamma rays travel relatively long distances in air, and leave a low density of ionization damage in their track through tissue. Gamma-emitting radionuclides are hazards from outside the body because their radiation penetrates to living tissue, but they are of less concern than alpha-emitters when ingested or inhaled, because their ionizing energy is deposited less effectively in tissue.

**Half-life, radioactive** – the time required for half the atoms of a radioactive substance to disintegrate. During one half-life, the number of radioactive atoms in a material is reduced by one-half. Each radionuclide has a unique half-life. Tritium decays with a half-life of 12.3 years, and plutonium-239 decays with a half-life of about 24,000 years.

**HASL** refers to the Health and Safety Laboratory, in New York City, operated by the Department of Energy and its predecessors, is known for long-term global monitoring of radionuclides in the environment

and for development of analytical techniques for measuring radioactivity in environmental *media*. Later became known as the Environmental Measurements Laboratory (EML).

**Health Effect** is the result of exposure to substances (such as radiation) that cause harm to a person's health – including cancers, birth and genetic effects, and other diseases.

**Health physics –** an interdisciplinary science focused on the radiation protection of humans and the environment. Health physics combines the elements of physics, biology, chemistry, statistics, and electronic instrumentation to protect individuals from the effects of radiation.

**Heavy water** – water in which nearly all of the hydrogen is the heavy isotope, deuterium; deuterium oxide ($D_2O$).

**Heavy Water Plant–** a facility in the D Area at SRS that began producing heavy water (deuterium oxide) in 1953 to moderate and cool the site's reactors. The facility stopped production in 1981 because there was a sufficient supply of heavy water.

**HEPA filter** – a high-efficiency particulate air filter used to remove contaminants from exhaust gases prior to discharge.

**Ingestion –** radionuclides or chemicals taken into the body by eating or drinking are taken in by ingestion.

**Inhalation –** radionuclides or chemicals taken into the body by breathing are inhaled.

**Inventory –** the total amount of a *contaminant* in a defined space, e.g. the amount of *plutonium* in the *sediment* of a reservoir.

**Ion exchange –** a process for selective removal of a chemical constituent from a particular solution.

**Ionizing radiation –** radiation sufficiently energetic to dislodge electrons from an atom and thus leave the atom positively charged or "ionized." Ionizing radiation includes x and gamma radiation, electrons (beta radiation), alpha particles (helium nuclei), and heavier charged atomic nuclei. Neutrons ionize indirectly by colliding with atomic nuclei. The creation of ions (ionized atoms, which are chemically active) inside living cells can damage key substances in cells, including the DNA containing the record of the cell's characteristics. Such damage can lead to cancer or other defects.

**Isotopes –** different forms of elements having the same atomic number (number of protons) but different numbers of neutrons. Different isotopes of a particular element generally have essentially identical chemical properties. Plutonium-239 and plutonium-240 are isotopes of plutonium that can not be distinguished from one another by typical *analytical methods*.

**kilo –** a prefix that multiplies a basic unit by 1000. For example, 1 kilogram = 1000 grams.

**Liter (L) –** A metric unit of volume, equivalent to about 1.1 quarts.

**Long-lived radionuclides**, in this study, refer to radionuclides with *half-lives* greater than 15 days.

**Mean** – the average of the values in a distribution. The sum of all of the values in the distribution divided by the # of values in that distribution.

**Median –** the central point of a distribution. Half of the values are larger than the median value and half are smaller. *(See percentiles.)*

**Micron –** a micrometer or micron is a unit of length equal to one-millionth ($10^{-6}$) of a meter. A human hair, for reference, is about 100 microns thick.

**Minimum detectable concentration (or activity)** is the lowest *concentration* of a *contaminant* (or amount of radioactivity) that can be detected with a certain degree of confidence by an *analytical method (detection level*).

**Monitoring** – obtaining measurements at regular time intervals.

**Monte Carlo procedure** is a method that uses computer-generated pseudo-random numbers to make calculations with statistical distributions. In this study, Monte Carlo methods have been used to estimate statistical distributions that represent uncertainties in estimated quantities, such as source term release estimates. This approach contrasts with a deterministic approach in which a calculation is based upon point estimates of the various parameters and yields a single result. The Monte Carlo calculation carries the underlying uncertainty in the parameters forward and displays it in the magnitude of the distribution of results. A statistical risk management computer program, called Crystal Ball™ (Decisioneering 1993) was used in this study for some of the uncertainty analyses.

**Naturally occurring radionuclides** are radionuclides that are naturally present in the environment.

**NCEH** (National Center for Environmental Health) – One of the CDC's centers, the NCEH is involved in health studies of the Savannah River Site community and has lead responsibility for the SRSHES.

**NCRP** (National Council on Radiation Protection and Measurements) – The NCRp produces recommendations concerning all aspects of radiation protection, including many reports defining recommended methods for performing key aspects of Dose Reconstruction (i.e. screening).

**Neutron –** an uncharged subatomic particle capable of producing ionization in matter by collision with charged particles. Approximately the same mass as a proton it is a constituent of the nuclei of all atoms except hydrogen. The nucleus of deuterium (heavy hydrogen) has one proton and one neutron.

**Noble gases –** the name given to the following group of elements: He, Ne, Ar, Kr, Xe, Rn which all have closed-shell electronic structures that are completely stable.

**Nuclear materials** - materials used to produce a nuclear reaction such as uranium and plutonium.

**Nuclide** – a species of atom having a specific mass, atomic number, and nuclear energy state.

**pico** – a prefix that multiplies a basic unit by 1/1,000,000,000,000 or $1 \times 10^{-12}$. For example, 1 picocurie equals $1 \times 10^{-12}$ curie, or one-trillionth of a *curie*.

**Percentiles** are defined in such a way that a large set of data, arranged from its smallest to its largest value, is divided by its percentiles into 100 classes containing nearly equal numbers of data. The exact rules for defining the percentile numbers are complicated, but the effect is that approximately 5% of the data are less than or equal to the 5th percentile, and approximately 95% of the data are greater than or equal to the 5th percentile (similar statements hold for the other percentiles). The median is defined as the 50th percentile, which divides the data (approximately) into halves (if there are an odd number of data, the middle value is the median; if there are an even number, the average of the two middle values is the median). In this document, uncertainty distributions are indicated by their 5th, 50th, and 95th percentiles. Observations above the 95th percentile have only a 5% probability of occurrence, as do observations below the 5th percentile. The 50th percentile is presented as the best estimate.

**Plume** – the *concentration* profile of an airborne or waterborne release of material as it spreads from its source. A plume from a coal-fired power plant, for example, may be visible for some distance from its stack, with the concentration of its components decreasing with distance from the stack and from the centerline of the plume. After the plume becomes invisible because of dilution, it continues to be diluted

with increasing time and distance. Atmospheric dispersion *model*s of this process predict concentrations within a plume far downwind and far beyond the point at which a plume becomes invisible. Similar modeling for releases from nuclear facilities can estimate the impacts of releases long past by reconstructing *exposure* and *dose* estimates.

**Plutonium (Pu) –** Silvery, white radioactive metal (atomic number 94) used in casting, rolling and forming, and machining and final assembly of nuclear weapons components. Its most important *isotope* is plutonium-239, produced by neutron irradiation of uranium-238. Plutonium-239 decays by emitting *alpha particles* and has a 24,065-year half-life.

**Precision –** the ability of an *analytical method* to reproduce the same result upon repeated trials. (*See bias.*)

**QA/QC –** Quality assurance/quality control programs are established to assure accurate and reproducible results from environmental *monitoring*.

***RAC* – *Radiological Assessments Corporation***, the contractor selected in October 1992 to conduct the Phase II Toxicity Assessment and Risk Characterization.

**Radiation –** Energy moving in the form of particles or waves. Familiar radiations are heat, light, radio waves, and microwaves. *Ionizing radiation* is a very high frequency form of electromagnetic radiation. It is invisible and cannot be sensed without the use of detecting equipment.

**Radioactive contamination** – *Radioactive material* distributed over an area, equipment or an individual.

**Radioactive decay** – the disintegration of the nucleus of an unstable nuclide by the spontaneous emission of charged particles or photons of energy.

**Radioactive material** contains unstable (radioactive) atoms that give off *radiation* as they decay.

**Radioactivity** –Spontaneous transformation of an unstable atom, often resulting in the emission of *radiation*. This process is referred to as decay or *disintegration* of an atom.

**Radiological –** related to *radioactive materials* or *radiation*. The radiological sciences focus on the measurement and effects of radiation.

**Radionuclide –** A radioactive *isotope*, for example, plutonium-239 or tritium. Plutonium-239 emits *alpha particle* radiation when it decays; tritium emits low-energy beta particles. The isotope is an element that may make up part of another substance or chemical compound.

**Reactor** refers to the nuclear reactors in the 100 areas.

**Risk** – The probability of developing a given disease over a specified time period.

**Seepage basins**–Unlined excavated bowl-shaped areas for receiving liquid wastes from numerous facilities onsite. They were designed to allow infiltration of the liquid into the ground, thus decreasing the total volume of liquid released to onsite streams. The first seepage basins were put into operation in 1954.

**Sensitivity –** ability of an analytical method to detect small *concentration*s of a *contaminant*.

**Separation areas** refer to the F-Area and H-Area where fissionable materials that had been irradiated in the reactors were chemically separated from fission products and from each other.

**Source term** refers to the quantity, chemical and physical form, and the time history of *contaminant*s released to the environment from a facility.

**Tank farm** – series of interconnected underground tanks used at SRS for storage of high-level radioactive liquid wastes.

**Time trend (or temporal trend)** describes how the *concentration* of a *contaminant* changes over time at the same place.

**Toxicity assessment** – an evaluation of the types of health effects usually caused by specific substances, and the quantity (or *dose*) required to cause the effects.

**Toxicologic review** –an evaluation of the presence, use, and possible releases of toxic substances and the resulting potential for *exposure* or hazard to occur.

**Transuranics** – nuclides having an atomic number greater than uranium (i.e., greater than 92); all known transuranium elements are radioactive.

**Tritium** (T) – synonym for $^{3}H$, a radioactive isotope of hydrogen of triple mass (atomic mass = 3).

**Tritium** reservoirs are small pressure vessels of various shapes that were filled with tritium gas under high pressure for use as components of a thermonuclear weapons. These are the only weapons components that were produced at the SRS.

**Uncertainty** is a general term used to describe the level of confidence in a given measurement or estimated quantity. Uncertainty depends on the amount and quality of the evidence (data) available. Uncertainties in the results of this study arise primarily from *bias* and imprecision in available measurements, absence of measurements at some times and places, lack of knowledge about some physical processes and operational procedures, and the approximate nature of mathematical models used to predict the transport of released materials.

**Uranium (U)**–a naturally occurring radioactive metal with atomic number 92, the heaviest natural element. Small amounts are present in soil, coal and rock materials, water, plants, and animals.

**Validation**–the process of comparing predicted *concentration*s of a material in the environment, based on *source term* reconstruction and environmental transport *models*, with historical measured concentrations to demonstrate that the models, within their domain of applicability, adequately represent the system they are intended to describe.